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ABSTRACT

Leading-edge technologies, integrated with emerging educational methodologies, make the Advanced Learning Environment (ALE) model cost effective and efficient for learning. The ALE integrates virtual reality and other enabling technologies such as natural language processing, animation, video, courseware, sound, projection, CD-ROM, and distance learning, with advanced educational methodologies, learner questions, records, and tracking to present optimal learning environments. The resulting multimedia environment is well suited for acquiring cognitive skills and knowledge about the processes, procedures, and sequence of actions necessary to perform an assigned task. The process for creating the ALE includes determining the tasks to be performed, the skills required for performing the task, and the optimal learning environment for acquiring these skills. In the ALE, educational methodologies are modified so that learners can do the following: (1) learn through tasks, projects, and assessments that integrate information across subject matter; (2) learn by selecting among the full range of technology-based tools, resources, and methods; (3) work constantly with real-world projects, problems, and activities; (4) work on different projects, either in a group or singly, in a variety of areas; and (5) collaborate, communicate, and interact with other learners, the instructor, and other workers on the job, as part of learning. The components of the ALE include state-of-the-art facilities, infrastructure, materials, a training support package, and evaluation. (KC)

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ADVANCED LEARNING ENVIRONMENTS

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Leading-edge technologies, integrated with emerging educational methodologies, now make the Advanced Learning Environment (ALE) model cost effective and efficient for learning. This paper describes the ALE concept and issues associated with effectively using these environments.

The ALE integrates virtual reality and other enabling technologies such as natural language processing, animation, video, courseware, sound, projection, CDROM, and distant learning, with advanced educational methodologies, student questions, records and tracking to present optimal learning environments. The resulting multimedia environment is well suited for acquiring cognitive skills and knowledge about the processes, procedures and sequence of actions necessary to perform an assigned task. When appropriate (e.g., training for maintenance technicians), the ALE integrates the multimedia environment with physical hardware trainers to support practicing and mastering the motor and mechanical skills required for the task being trained. The integration of multimedia and physical hardware trainers provides a more complete learning experience in less time and for less-life cycle cost. These environments are excellent for training involving equipment that is costly or does not yet exist in quantity, tasks that are dangerous, and for supporting surges in student populations.

The process for creating the ALE includes determining the tasks to be performed, the skills required for performing the task, and the optimal learning environment for acquiring these skills. As multimedia learning environments are developed, there is sensitivity to ensure that the needs and expectations of both students and instructors are considered. The facility supports a range of educational modes that include immersive classroom environments and group study. The ALE can also be used for conducting evaluations in a controlled setting. The components of the ALE include state-of-the-art facilities, infrastructure, materials, a training support package, and evaluation.

AUTHORS BIOGRAPHIES

Robert C. Hubal holds a Ph.D. in Cognitive Psychology and an M.S. in Computer Science, and has been involved for a number of years in improving the application of technology to education. He is currently heading up an experimental evaluation for the Army National Guard of the effectiveness of virtual maintenance trainers. He is also working with selected North Carolina school systems on a proof-of-concept for instituting advanced learning environments to improve learning of mathematics by low-performing students. Dr. Hubal provides on these projects a link between learning theories and technological capabilities.

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INTRODUCTION

It is now feasible to use leading-edge technologies for meeting Department of Defense (DoD) education and training needs. The increasing capabilities and declining costs of advanced computer hardware, software, and ancillary tools have the potential for revolutionizing education and training in the armed forces. There is a range of current initiatives across the DoD, such as the XXIst Century Classroom, distant learning, and electronic classrooms, leveraging advanced technology for education and training.

However, advanced technologies alone, even with the accompanying glamour and splash, will not provide the full range of benefits. In fact, technology alone may not add value at all to traditional classroom instruction and may serve as a distraction.

We describe an *advanced learning environment* (ALE) as a system of facilities, hardware, software, curriculum, and learning methodologies for fully realizing the potential of today's technologies for education and training needs. The ALE ensures that disappointments are minimized, perhaps avoided altogether. *It is the purpose of this paper to present a complete learning model, the ALE, that we believe is necessary to exploit technology for maximum learning in military and civilian settings.*

RATIONALE FOR THE ALE

Significant lessons can be learned from the introduction of technology, especially computers, into public schools and post secondary institutions. More often than not, the computers remain in the computer lab, sometimes in the back of the classroom, sometimes in the back of the closet. There is little integration of technology into the instructional or learning process. At best, the computer has been used for drill-and-practice exercises, but the promise of computer-assisted instruction has never been realized. This critical failure of technology in our schools portends problems that will be encountered with the rapid deployment of technology into the military training program, often for the sake of technology. These known mistakes and the problems they engender can be avoided with careful rethinking of how learning and technology interact. Psychologists and educators are beginning to understand some of these important educational issues, including emerging research on how the brain functions and how people learn. Much of the old pedagogical theory is being replaced; new ways of teaching are being developed to account for the new knowledge of how students learn. The emerging uses of technology in military training present an opportunity to incorporate the new knowledge as new installations are developed.

Constructivist Learning

For example, an advanced desktop computer is capable of portraying a virtual environment in which the learner guides program flow by naturalistic interactions. Two learners interacting independently with the same virtual environment will experience different learning environments; learners actively construct the learning environment. This *constructivist* paradigm much better describes learning that takes place in virtual environments (Moshell & Hughes, 1996; Winn, 1993), compared with the still-dominant *information transfer* paradigm which holds that knowledge is imparted to the largely passive learner. Information transfer is necessary in some learning contexts, but is not optimal in all contexts.

Types of Knowledge

There are other distinctions researchers make which pertain to traditional and advanced learning environments. Psychologists often separate knowledge into *procedural* versus *declarative*, where procedural knowledge is knowledge of skills and processes, while declarative knowledge is factual, specific, easily expressed. Declarative knowledge is best presented by words (spoken or written), symbols, lists, outlines, and some graphics. If a learner can gain the knowledge off of a chalkboard, it is declarative. Procedural knowledge is best gained, on the other hand, by doing. Learning to drive, learning to play chess (as opposed to learning its rules), learning to obtain research funding, are all examples of procedural knowledge.

True learning involves gaining both types of knowledge. Thus, for instance, a neophyte learning to play chess must gain both the rules of play as well as the nuances and strategies that mark a chess master. Chess strategy involves both recognition of patterns (primarily a procedural task) as well as knowledge of the best move (a declarative task, since the chess piece then gets moved). An equivalent assertion holds, for instance, for maintenance training of a Bradley fighting vehicle. Not only must the soldier learn what each piece of equipment does and where it is located (a declarative task), but also the soldier must learn to diagnose and repair the equipment (procedural tasks).[1]

Learner Characteristics

Learner characteristics play an important role in the design of advanced educational methodology. Some educators differentiate along dimensions such as *extroverted* vs. *introverted*, *intuitive* vs. *sensing*, *feeling* vs. *thinking*, and *judging* vs. *perceptive* (Keirsey & Bates, 1984). An individual who is intuitive and thinking might follow certain paths through an interactive learning environment, while another who is sensing and feeling might follow alternate paths. A successful ALE will allow both individuals to reach the same understanding of the material. Another highly influential separation is of intelligence into an ability to carry out at least seven separate forms of analysis: *linguistic*, *logical*, *musical*, *spatial*, *kinesthetic*, *interpersonal*, and *intrapersonal* (Gardner, 1983). Alternative methods of presentation of to-be-learned information will allow two individuals with different abilities to gain the knowledge that they need in ways they are most able.

Alternative representations are novel to the ALE concept put forth here. If a *representation* is the visual, auditory, and motor environment that a learner encounters, *alternative representations* are alternative portrayals of the same information (see Day, 1988; Simon, 1992). A simple example involves tables and graphs; a table of numbers can be transformed into a graph of that information, and vice-versa. Neither presentation is superior to the other. Instead, graphs are useful for recognizing patterns and making inferences from the data, whereas tables are useful for learning specific values and noting positional information.

The learning requirement, as well as learner characteristics, form a context which dictates which representation is preferable. A more complicated example might be the same virtual environment that two individuals encounter but who follow different paths through the environment. It is the same environment; what one individual can learn from it the other can as well. However, the two gain this knowledge in very different ways. One may prefer to follow links in a systematic fashion, constantly viewing sources of data that underlie summary charts presented and allowing learning to be guided by a tutorial. The other might prefer to meander through the environment, choosing paths at whim but always with a view toward integrating new knowledge with existing knowledge. A successful ALE supports this creativity in learning.

CONCEPT

We assert that the ALE model allows for training more students more effectively, and in less time at significantly lower costs. Indeed, we believe that the ALE model provides more than an order of magnitude of improvement, measured in terms of efficiency (i.e., less time and money) and effectiveness (i.e., more knowledge and skills), relative to current methods.

The concept for the ALE moves well beyond the simple technology solutions being applied to education and training, though technology is crucial. Equally crucial, however, is the integration of emerging educational methodologies and evaluations with technology. Traditional educational methodologies have failed to leverage all the capabilities inherent in, and opportunities presented by, technology in an integrated learning environment.

The ALE integrates technologies with educational methodologies and evaluations to provide significantly improved learning at reduced costs.

The methodologies address issues associated with how best to use the technologies and the evaluations provide information needed to determine the effectiveness and efficiency of the learning environment.

The concept of an ALE is sensitive to the issue of "If it isn't broken, don't fix it." An ALE is not a solution looking for a problem to solve; rather it is a concept which seeks to pull together and integrate the new research on how people learn and the new technologies and technology applications that are being developed almost daily.

The centerpiece of the ALE is computer-generated

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presentations of information which can be integrated with other presentation media, including traditional instructional presentations that use student handouts, paper handouts, group studies, etc. Our intent is not to stop using what makes sense, but to find and use the best mix to meet the learning styles and needs of the learner with the desired knowledge and skills outcomes. The goal of the ALE is to determine the optimal mix that satisfies both effectiveness (learning) and efficiency (costs).

The computer generated presentation environment, particularly those which include higher levels of interactivity, is well suited for acquiring cognitive skills and knowledge about processes, procedures and sequences of actions. When it is appropriate (e.g., training for maintenance technicians or equipment operators), the computer-based environment can be integrated with physical hardware trainers to support practicing and mastering of the motor and mechanical skills required for the task being trained.

The integration of virtual and physical hardware trainers has the potential of providing a more complete learning experience in less time and for less life-cycle cost. These environments are excellent for training involving equipment that is costly or doesn't yet exist in quantity, tasks that are dangerous, and for supporting surges in student populations.

APPROACH

The success of the ALE starts with a sound design which satisfies the needs of those being trained and those responsible for delivering the training. The goal is to create an environment within which a student can acquire the skills necessary for performing specific tasks, and in which the instructor can deliver individualized training for different students. This goal includes considering and including the expectations and needs of the student and the instructor, and integrating components of the ALE into a coherent package.

The New Adult Learner

The ALE actively engages students to acquire skills for performing specific tasks.

The reality is that elementary, secondary, and post secondary schools and society are changing rapidly, resulting in different types of adult learners. Young adults entering the workforce and job training in the year 2001 will be much more advanced in basic skills than those that preceded them (e.g., there are some estimates that the high-school graduate at the turn of the century will be performing at the same level or higher than college sophomores of a decade ago), will have new, more participatory learning skills, will be more sophisticated and knowledgeable of the world around them, and will have had significant formal and informal experiences with technology and multimedia.

Young learners also increasingly need to learn to work in teams. Rarely does one individual perform all of the work on a task. Instead, a team (e.g., a vehicle maintenance team, a surgical team) that is not always composed of the same individuals must perform the task. The ALE model allows for collaborative learning. Students can take any of multiple roles, learning to perceive problems from alternate angles, and can establish social and leadership skills in safe learning environments that will be critical in actual performance environments.

It is important to understand the differences in the learning experiences between young and older adult learners if we are to take advantage of the strengths and perspectives they are bringing to skill and job training today. The ALE must start where the adults are as learners and build on their past experiences, or suffer the consequences of taking students with advanced knowledge and learning skills, and with specific needs, and stifling their growth.

The New and Existing Instructors

The ALE enables complementary instruction techniques and individualized instruction.

There have always been differences in instruction style between teachers in different classrooms; what works for one teacher will not necessarily work for another. There is no reason to believe that introduction of technology into the learning environment will create one standard of instructional technique. In contrast, the introduction of technology can magnify the effects of different techniques.

Some instructors have changed along with students, having been quick to embrace technology, integrating the latest knowledge of educational practice within their classrooms, and adapting to advances in the technology. These instructors will always push the edge of technology in education. Other instructors, however, demand that any technology introduced into their classrooms itself

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adapt to their teaching styles. An ALE affords the greatest flexibility yet for alternative instructional styles in using technology in education. Instructors must be able to demonstrate creativity and change in their own fashion as they feel comfortable.

An ALE also permits individualized instruction, in at least two ways. First, learning environments can be tailored to, and by, the individual student. The teacher can tailor a given learning situation differently for two different students (e.g., by introducing different faults into a virtual tank engine for different students, or specifying more strict rules of valid actions for one student at a more advanced level than another). Students can tailor the environment themselves, taking different paths in maneuvering through a learning situation, allowing an online tutorial to guide them at their discretion.

Second, the ALE can handle some of the instructor's traditional responsibilities, allowing more time for the instructor to focus on other tasks. For instance, measurement of knowledge gain through tests and scenarios can be automated. Indeed, it is relatively easy for the technology to measure, in addition to accuracy of responses, timing and error patterns, which can be great sources of information on student misconceptions. Similarly, online tutorials can guide learning for some students, lessening the need for the teacher to provide guidance. Also, students can spend additional time interacting with the technology, outside of classroom time. In fact, evidence from classrooms already having integrated technology suggests that students do spend additional hours enjoying and learning. This leaves additional time for instructors to offer any remedial help necessary to low-performing students.

Educational Methodologies

In the ALE, many conditions change, resulting in different teaching and learning strategies and modes. The ALE provides an active, flexible environment, open to the full range of experiences of the adult learner. Changed learner roles and activities provide learners with more opportunities to master higher level skills, to practice effective communication, and to work individually and collaboratively with others on significant tasks.

Changed modes of instruction permit learners to actively engage in and manage the learning activity. Instruction in the ALE:

- Is based on authentic applications as close to real-world situations as possible, either hands-on in the work environment, virtual reality, simulations, or remote learning.
- Engages the learner in meaningful manipulation of information and creation of new knowledge.
- Is integrated across subject matter.
- Incorporates multiple approaches to accommodate and enhance the various adult learning styles.
- Provides immediate feedback.
- Is based on specific learner outcomes.

Changed instructor roles and activities enable instructors to provide direction, momentum, and motivation to all learners, regardless of levels of proficiency and learning styles. Instructors in the ALE:

- Spend the majority of time interacting with students as mentors, guides, and resources for activities controlled, to a large extent, by the learners.
- Provide teaching demonstrations as needed, working as needed with students to develop individual goals and learning plans and to schedule resources for learning.
- Spend time as needed at computer workstations to analyze data for resource management decisions, explore, acquire, or reserve instructional tools and resources, maintain records, communicate with peers, supervisors, job supervisors, and learners, and access resources.

Changed venues for learning include individual and small group learning in remote locations, in the classroom, on the job, at home, and elsewhere. Changed times for learning extend beyond traditional classroom schedules to enhance individual and collaborative learning beyond the regular school and work day.

In the ALE, educational methodologies under these conditions are modified so that learners:

- Learn through tasks, projects, and assessments that integrate information across subject matter.
- Learn by selecting among the full range of technology-based tools, resources, and methods: modeling, simulation, distance learning, network communications, self-assessment, idea testing, desktop publishing, etc. No one media or method dominates. The media matches the learning goal and the needs of the student.
- Work constantly with real-world projects, problems, and activities, which are integral to

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and ongoing in daily work.

- At any given time, are working on different projects, together or individually, in a variety of areas: class conference room, virtual stations, simulations, in the library or computer room, at the fax machine, on the telephone, out in the work environment, or at home.
- Collaborate, communicate and interact with other learners, the instructor, other workers, on the job, as part of learning.

ALE Components

An ALE has five components: facilities, infrastructure, materials, a training support package, and evaluation.

Facilities and Infrastructure

The physical facilities house the ALE. These facilities, depending on the requirements of the learning environment, may be at multiple locations.

The infrastructure includes those capabilities such as computers, LANs, switching units, projectors, sound systems, air conditioning, and power necessary for the ALE to function.[2]

Examples of the capabilities which can be integrated in an ALE include virtual reality, natural language processing; animation; video; courseware; sound; projection; CD ROM; student testing, feedback, and records.

Materials

The material is the educational and training substance (often computer software) used by students and instructors to support their learning. These materials are easily replaced with different materials so that the same facilities and infrastructure can be used for different training needs: they can be added to as new training requirements arise, and they can be updated when necessary as training requirements change.

Training Support Package

The training support package enables both students and instructors to use the capabilities with minimal training requirements. It involves the integration of advanced educational methodologies and smart use of alternative representations to make the ALE readily usable.

Evaluation/Experiments

The evaluation provides data necessary for determining how well learning is taking place, as well as a knowledge base for making informed decisions to improve the learning environment. The ALE model allows for capture of all types of student information that the instructor feels would be useful.

The ALE can also be used for conducting experiments in a controlled setting. One focus of experimentation is on support of research and evaluation of new technology in education. Another focus is on the effectiveness and efficiency of traditional, virtual and hands-on training environments, to determine the optimal use and return on investments for these environments.

These experiments provide the scientifically-based data needed for determining the effectiveness and efficiency of alternative educational and training tools and environments. While considerable research has gone into investigating the effects of certain kinds of technology introduced into the classroom (e.g., computer-based tutorials, simulations; see Fletcher, 1992; Orlansky et al., 1994), very little research has systematically investigated how different technologies work with different types of learners and instructors. Furthermore, technologies change rapidly, leading to a need for better communication between educational methodologists and technologists. The ALE concept is our attempt to overcome this limitation in current understanding and practice.[3]

DESIGN

Design Process

The process for designing an ALE is simple. It starts with first determining the tasks the students are learning to perform; then, once the tasks are known, the skills required for performing the task are determined; then, the optimal learning environment for acquiring these skills is designed based on what we now know from the research. This simple process can be considered to be an appropriate ISD methodology for the ALE.

Task to be performed → Skills required to perform the task → ALE design that supports acquiring the skills necessary for performing the task

As the learning environment is designed, there is sensitivity to ensure the needs and expectations of students are considered. Additionally, advanced educational methodologies are incorporated to realize maximum efficiencies and effectiveness.

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Key Features of the Design

The ALE design must take into consideration a number of key features that include:

- Flexibility
- Adaptability
- Scalability
- Growth Potential
- Affordability

The ALE can be a major commitment in resources and for changing the way education and training is conducted. As such, it cannot be undertaken lightly and care is needed to ensure the outcome is correct. This design should consider including, whenever feasible, the integration of capabilities that exist and that the customer can make available to reduce costs and to help the customer accept the ALE.[4] Examples of the capabilities which can be considered for integration include computers, LAN, multimedia lessons, and fiber optic cables.

The design can be sensitive to resource requirements and, if resources are constrained (as they normally are), provide for a learning environment which can be adapted and used for multiple purposes.

An ALE that is flexible and adaptable can be expected to be more cost effective than one that can be used for only a single purpose.

The design of the physical components for the ALE (facilities, infrastructure, and training support package) is purposefully adaptable to support multiple uses. It may be necessary for minor adaptation of the physical components to support multiple uses, such as substituting a different physical hands-on trainer, but the significant change is the use of different materials which, for the ALE, are primarily software databases that are application specific. The computer hardware, run-time software, and ancillary equipment can be selected to support a number of education and training requirements.

It would not be unusual for the funding needed for an ALE to be spread over time, perhaps several years; indeed, this situation should be anticipated.

The ALE design must be consistent with the resources available now and expected in the future an unaffordable design is of little or no use.

The design can be a phased master plan which provides capabilities consistent with funding available now, and which can be added to as additional resources become available. The attractive features of this approach include:

- Providing useful capabilities with the resources that are available now to support near term education and training benefits.
- Learning to use the ALE and develop strategies for optimizing the investment, including training and getting instructors comfortable with the ALE.
- Conducting experiments for obtaining data to support future investments.
- Having a coherent master plan which can be used for adding complementary capabilities as additional resources become available and for supporting requests for additional funding.

Design Team

The ALE is a multidisciplinary environment. It includes leading edge technologies; software; databases; advanced educational and training methodologies; creation and presentation of multimodal forms of information; and experiments to collect data for analyses. The design team should include individuals knowledgeable in each of these areas. It is also important for these team members to be aware of developments underway, but not yet mature, for these areas and able to accommodate these in a forward looking design.

SUMMARY

Leading edge technologies, integrated with emerging educational methodologies, now make the ALE model increasingly cost effective and efficient. This paper describes the ALE concept, rationale, approach and design issues associated with effectively using these advanced learning environments.

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[1] A virtual maintenance trainer already developed by RTI for the Army National Guard enables cost-effective learning of declarative knowledge. Combined with a hands-on trainer, the ALE enables procedural knowledge gain as well.

[2] The paper presented by Dr. Geoffrey Frank at this conference provides a more in-depth description of the physical facilities and infrastructure necessary to support the ALE.

[3] The authors are currently conducting a formal experiment with the Army National Guard on the effectiveness of a virtual reality application for maintenance training. The experiment has been carefully designed to evaluate the effects of learning environment (advanced vs. traditional) and experience (prior maintenance experience vs. none) on maintenance training, using such measures as accuracy of performance and error patterns. We have developed a model for evaluating training in the ALE that considers acquisition and retention of learned material, time required to learn it, interest in learning, and costs involved. The experiment will be complete by the time of the conference and results will be made available.

[4] It can be difficult to discard or not use capabilities already purchased. Including these capabilities may make it much easier for the customer to accept the ALE and to defend it as a logical extension of other efforts.

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